FINAL REPORT

1 JANUARY 1992 - 31 DECEMBER 1993

TO

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

GRANT NO. NAG5-306

FROM

THE UNIVERSITY OF TEXAS AT DALLAS

CENTER FOR SPACE SCIENCES

ION DRIFT METER RESEARCH

R. A. Heelis
Principal Investigator

The University of Texas at Dallas
P. O. Box 830688
Richardson, TX 75083-0688

DE IDM Research

Final Report 1-1-92 thru 12-31-93

Introduction.

The final activity period for the DE project has been particularly productive. This period has seen the final delivery of geophysical data sets to the National Space Science Data Center , the granting of three Ph.D. degrees from cumulative work on the project, the operation of automatic data access and display routines for the data, and an increased effort in research and publication of the data. As before the research activities, largely devoted to studies involving the dynamics of the ionosphere, utilize data from the IDM and the RPA and thus the work is not easily attributable to one or the other of these separately funded efforts. In this final report we provide brief descriptions of the work accomplished in the final phase of the program.

The Dynamics Explorer program has provided a significant opportunity for much of the community to participate in the data analysis and interpretation. The data, now residing in the national space science data center is a great legacy that should continue to yield important results for many years.

Research Activities.

1) Early in the lifetime of the DE 2 spacecraft, enhancements of the total ion concentration were noted at certain longitudes when the spacecraft passed through the equatorial region. This phenomena is attributable to an interaction between the instrument ground plane and the plasma, that manifests itself when the earth's magnetic field is oriented perpendicular to the plane [Cragin et al., 1993].

2) The DE 2 spacecraft carried instrumentation to measure the ambient electric field and the ion drift velocity vector. In the region above about 200 km, these two parameters are related by the expression $E = -V \times B$. Since these measurement techniques are used extensively to provide essentially the same information about ion drifts perpendicular to the magnetic field, it is appropriate to verify the relationships between them and the conditions under which they break down. This study provided important information regarding the importance of attitude determination, the relevance of the vehicle potential and the effects of energetic particle precipitation on both sensors. When these effects are included in treatments of the data the agreement between the different techniques for deriving the ion drift or the electric field perpendicular to the magnetic field, is quite remarkable [Hanson et al., 1993].

3) The DE 1 and DE 2 spacecraft were in coplanar orbits, thus affording the occasional opportunity to examine plasma conditions at widely spaced altitudes on the same magnetic field line. Data from DE 2 provide the ambient ionospheric conditions and a measure of the available field-aligned thermal ion flux that is supplied to higher altitudes. The DE 1 data indicate the fraction of the upward ion flux that is provided with escape energy and the particle pitch angle distributions can provide information on the nature of the acceleration process [Lu et al., 1992].

4) Measurement of the ionospheric zonal ion drift from the DE 2 spacecraft allow the details of local time and latitude distributions in this parameter to be investigated. This ion drift is influenced by the tidal motion of the atmosphere, by wind systems driven by high latitude heating and ion drag, and by the penetration of

magnetospheric electric fields from higher latitudes. The different local time signatures from these sources can be recognized in the data at different times and under different conditions and thus their relative contributions can be assessed [Heelis and Coley, 1992].

5) Rapid westward ion drifts have been observed equatorward of the auroral zone for many years, and the DE 2 spacecraft instrumentation is ideally suited for further investigation of the phenomenon. After recognizing these events, associated measurements of the energetic particle distributions and images of the aurora from DE 1 can be used to identify the presence and phase of substorm activity. The association of these so-called SAID events with the recovery phase of substorms can be verified and anticipated in terms of a model in which the separation of the ion and electron Alfven layers of the ring current provide the source for the poleward directed ionospheric electric field [Anderson et al., 1993].

6) The nighttime ionospheric zonal ion drift at F-region equatorial latitudes is typically associated with the dynamo action of the zonal neutral wind in the same region. It is thus expected that the local ion drift will be smaller than the local neutral wind. The DE 2 spacecraft is able to measure both of these parameters and the observation of a local time region, where this condition is not realized, requires further examination. Calculations can be used to show that an altitude gradient in the neutral wind may provide an additional source for a divergent current that can enhance the electric field above the normally anticipated values [Coley et al., 1994].

7) At high latitudes the sources of electromagnetic energy in the F-region reside at higher altitudes where magnetospheric processes operate and at lower altitudes in the E-region where the dynamo action the neutral winds are effective. The dominance of one of these sources over the other can be observed by noting the direction of the energy flow, the Poynting flux, along the magnetic field lines. Calculation of this quantity requires rather sophisticated treatment of the magnetic field and ion drift measurements on DE 2. Once accomplished significant insights into the conditions under which the energy flow changes and is modulated can be achieved [Gary et al., 1994].

8) Measurements of the ion drift velocity vector in the high latitude ionosphere, allows investigation of the configuration of the global convection pattern when the interplanetary conditions are quite different. It is found that during periods of northward IMF the pattern may not differ significantly from that expected during times of southward IMF. However, the unusually large two-cell pattern that exists at these times may have a significant contribution from electric field sources in the magnetospheric tail lobes [Burke et al, 1994].

9) The extensive complement of ionospheric measurements made on the DE 2 spacecraft can be used quite effectively to study the electrodynamics of aurora arcs. Significant advances have been made by relating the characteristics of precipitating particles with their source characteristics in the plasma sheet [Burke et al., 1994].

10) Reliable measurements of the ion drift velocity vector require that the effects of the vehicle potential be accounted for in calculation of the ram energy of the ions. The vehicle potential is dependent on the electron temperature to first order and by establishing the relationships between these two parameters it is possible to provide an independent measure of the vehicle potential to the least-squares fitting procedure for the ram ion drift. These relationships were derived for the lifetime of the DE 2

mission, thus enabling a more reliable calculation of the ram ion drift to be provided for the entire DE 2 data set [Anderson et al., 1994].

In addition to the work described here there are on-going research initiatives being continued by staff at UTD and by graduated students that have used their data analysis to establish research initiatives at other institutions. In this final period of activity we have granted 3 Ph.D. degrees that result directly from work in the DE program.

Ph.D.'s Granted.

The Ionospheric Signatures, Substorm Phase Relationship, and Electrodynamics of Rapid Sub-Auroral Ion Drifts, by Phillip Charles Anderson

Application of Poynting Flux Measurements to the Determination of Energy Transfer Rates in the High Latitude Ionosphere, by James Bennett Gary

Characterization of the Geometries of the High-Latitude Ionospheric Convection Pattern, by Christopher Francis Keating

Papers Published.

"Upflowing Ionospheric Ions in the Auroral Region," G. Lu, P. H. Reiff, T. E. Moore, and R. A. Heelis, *J. Geophys. Res, 97*, 16,855, 1992

"East-West Ion Drifts at Mid-Latitudes Observed by Dynamics Explorer 2," R. A. Heelis and W. R. Coley, *J. Geophys. Res. 97*, 19,461, 1992

"A Proposed Production Model of Rapid Subauroral Ion Drifts and Their Relationship to Substorm Evolution," P. C. Anderson, W. B. Hanson, R. A. Heelis, J. D. Craven, D. N. Baker, and L. A. Frank, *J. Geophys. Res., 98*, 6069, 1993

"Field-Aligned Drifts in SAID Events," R. A. Heelis, G. J. Bailey, R. Sellek, R. J. Moffett, and B. Jenkins, *J. Geophys. Res., 98*, 21,493, 1993

"A Comparison of in Situ Measurements of from E and -V x B Dynamics Explorer 2," W. B. Hanson, W. R. Coley, R. A. Heelis, N. C. Maynard, and T. Aggson, *J. Geophys. Res., 98*, 21,501, 1993

"Comparison of Low Latitude Ion and Neutral Zonal Drifts Using DE 2 Data," W. R. Coley, R. A. Heelis, and N. W. Spencer, *J. Geophys. Res., 99*, 341, 1994

"Coupling of Microprocesses and Macroprocesses Due to Velocity Shear: An Application to the Low-Altitude Ionosphere", G. Ganguli, M. J. Keskinen, H. Romero, R. A. Heelis, T. E. Moore, and C. Pollock, *J. Geophys. Res., 99*, 8873, 1994

"Equatorial Spacecraft-Plasma Interaction Phenomenon Observed with DE 2", B. L. Cragin and W. B. Hanson, *J. Geophys. Res., 98*, 19,141, 1993

"Polar Cap Potential Distributions During Periods of Positive IMF B_Y and B_Z," W. J. Burke, E. M. Basinska, N. C. Maynard, W. B. Hanson, J. A. Slavins, and J. D. Winningham, *J. Atmos. Terr. Phys., 56*, 209, 1994

"Auroral Ionospheric Signatures of the Plasma Sheet Boundary Layer in the Evening Sector," W. J. Burke, J. S. Machuzak, N. C. Maynard, E. M. Basinska, G. M. Erickson, R. A. Hoffman, J. A. Slavin, and W. B. Hanson, J. *Geophys. Res., 99*, 2489, 1994

"Modeling Ionospheric Convection During a Major Geomagnetic Storm on October 22-23, 1981," J. J. Moses, J. A. Slavin, T. L. Aggson, R. A. Heelis, and J. D. Winningham, *J. Geophys. Res., 99*, 11017-11020, 1994

"Spacecraft Potential Effects on the Dynamics Explorer 2 Satellite." P. C. Anderson, W. B. Hanson, W. R. Coley, and W. R. Hoegy, *J. Geophys. Res., 99*, 3985,1994

"Satellite Measurements Through the Center of a Substorm Surge," D. R. Weimer, J. D. Craven, L. A. Frank, W. B. Hanson, N. C. Maynard, R. A. Hoffman, and J. A. Slavin, accepted, *J. Geophys. Res.*, 1994

"Gravity Waves Near 300 km Over the Polar Caps", F. S. Johnson, W. B. Hanson, R. R. Hodges, W. R. Coley, G. R. Carignan, and N. W. Spencer, submitted to *J. Geophys. Res., 1994*